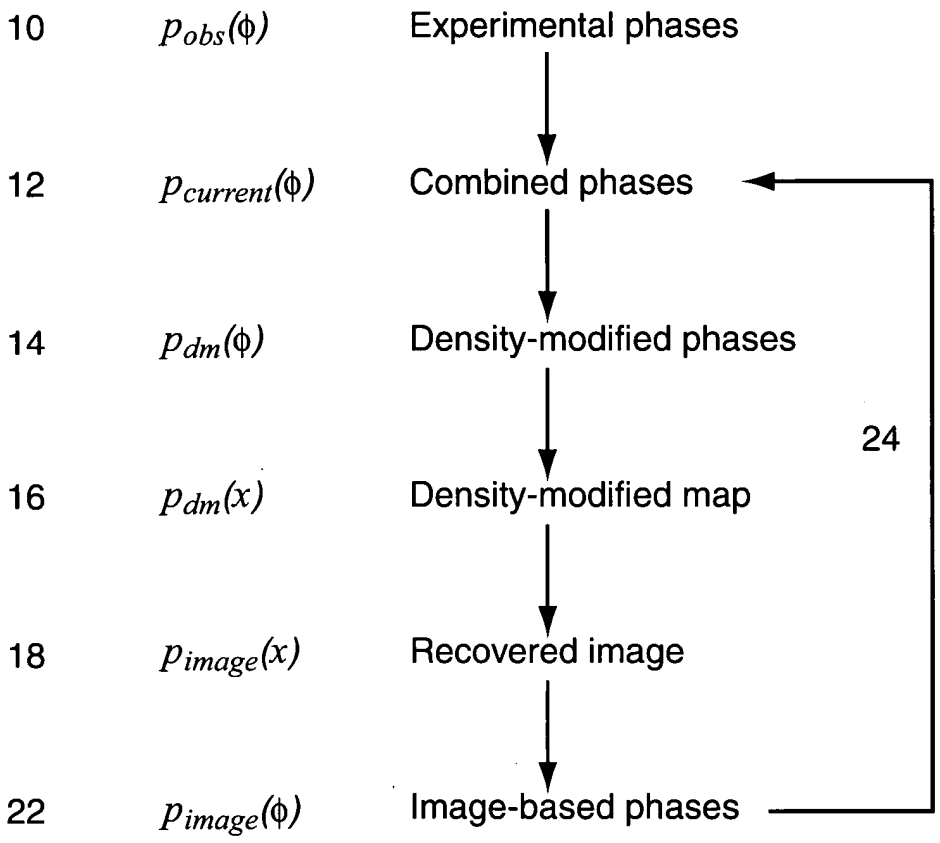
10
$p_{obs}(\phi)$
Experimental phases
12
$p_{current}(\phi)$
Combined phases
14
$p_{dm}(\phi)$
Density-modified phases
24
16
$p_{dm}(x)$
Density-modified map
18
$p_{image}(x)$
Recovered image
22
$p_{image}(\phi)$
Image-based phases

FIG. 1

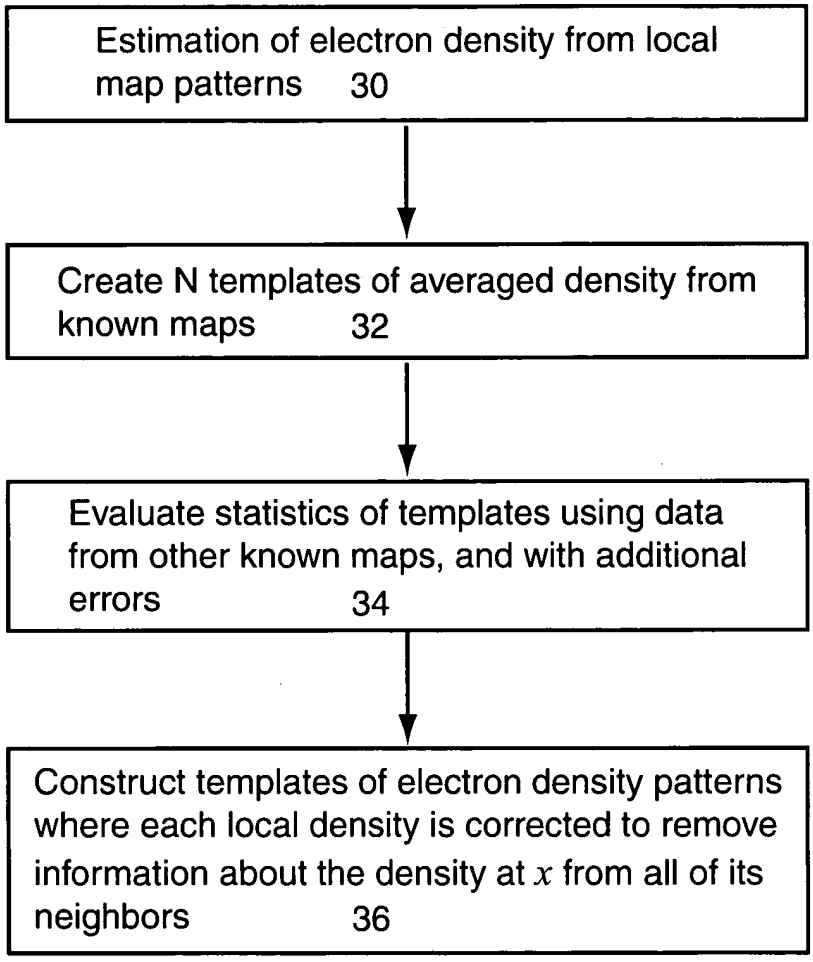
Estimation of electron density from local map patterns 30
Create N templates of averaged density from known maps 32
Evaluate statistics of templates using data from other known maps, and with additional errors 34
Construct templates of electron density patterns where each local density is corrected to remove information about the density at x from all of its neighbors 36

FIG. 2

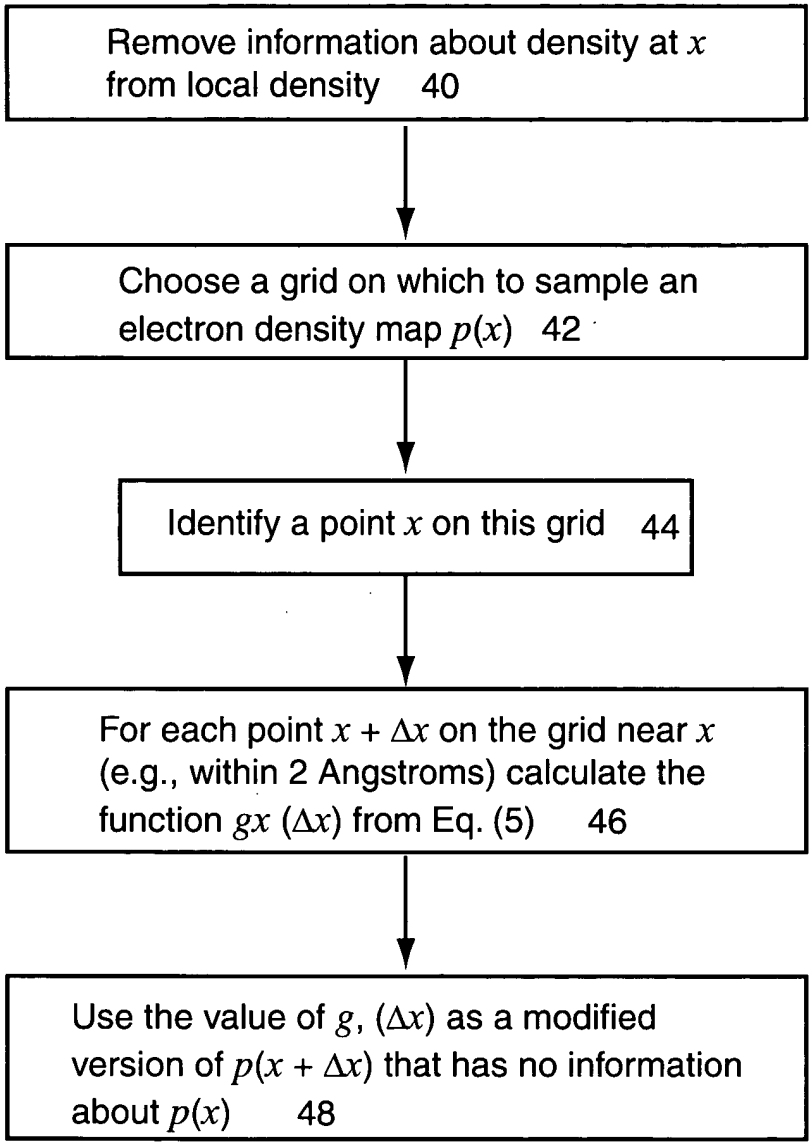
Remove information about density at x from local density 40
Choose a grid on which to sample an electron density map $p(x)$ 42
Identify a point x on this grid 44
For each point $x + \Delta x$ on the grid near x (e.g., within 2 Angstroms) calculate the function gx (Δx) from Eq. (5) 46
Use the value of g, (Δx) as a modified version of $p(x + \Delta x)$ that has no information about $p(x)$ 48

FIG. 3

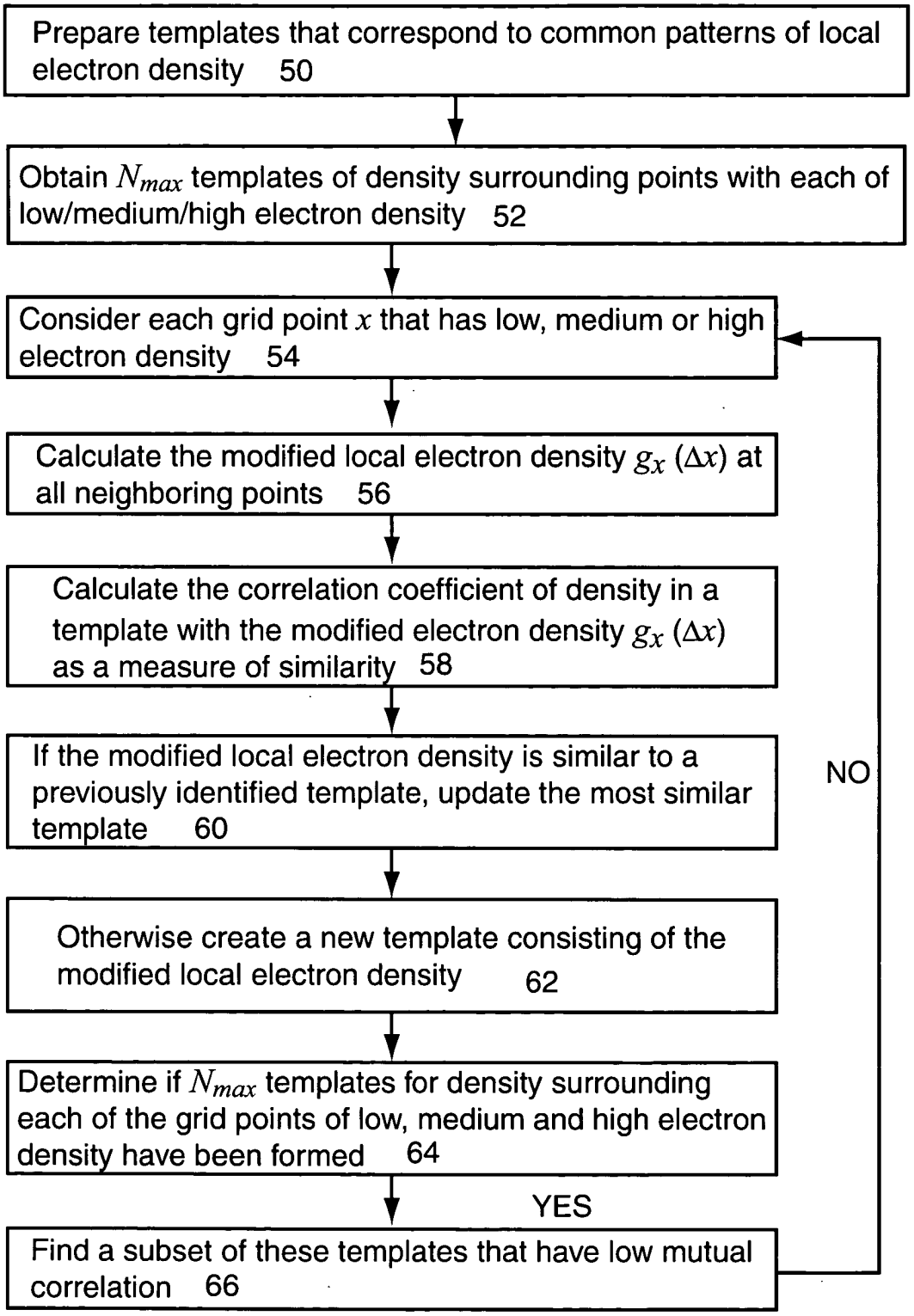
Prepare templates that correspond to common patterns of local electron density 50
Obtain N_{max} templates of density surrounding points with each of low/medium/high electron density 52
Consider each grid point x that has low, medium or high electron density 54
Calculate the modified local electron density $g_x(\Delta x)$ at all neighboring points 56
Calculate the correlation coefficient of density in a template with the modified electron density $g_x(\Delta x)$ as a measure of similarity 58
If the modified local electron density is similar to a previously identified template, update the most similar template 60
Otherwise create a new template consisting of the modified local electron density 62
Determine if N_{max} templates for density surrounding each of the grid points of low, medium and high electron density have been formed 64
NO
YES
Find a subset of these templates that have low mutual correlation 66

FIG. 4

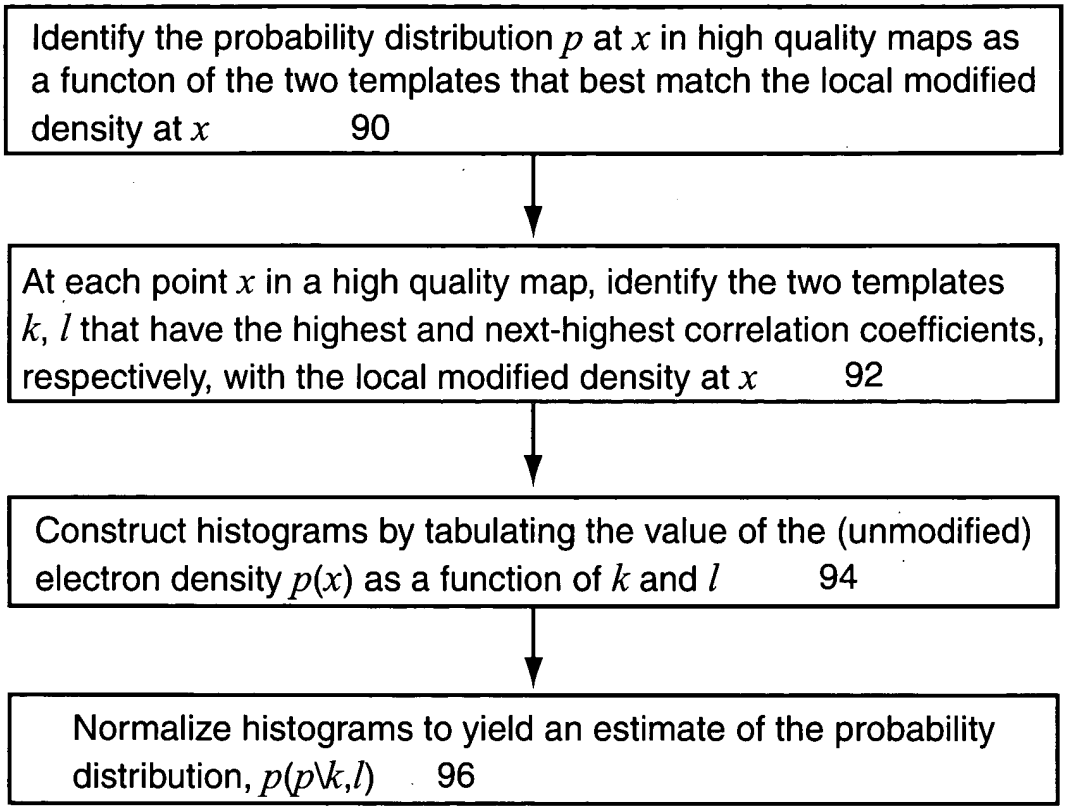
Identify the probability distribution p at x in high quality maps as a functon of the two templates that best match the local modified density at x 90
At each point x in a high quality map, identify the two templates k, l that have the highest and next-highest correlation coefficients, respectively, with the local modified density at x 92
Construct histograms by tabulating the value of the (unmodified) electron density $p(x)$ as a function of k and l 94
Normalize histograms to yield an estimate of the probability distribution, $p(p\backslash k,l)$ 96

FIG. 5

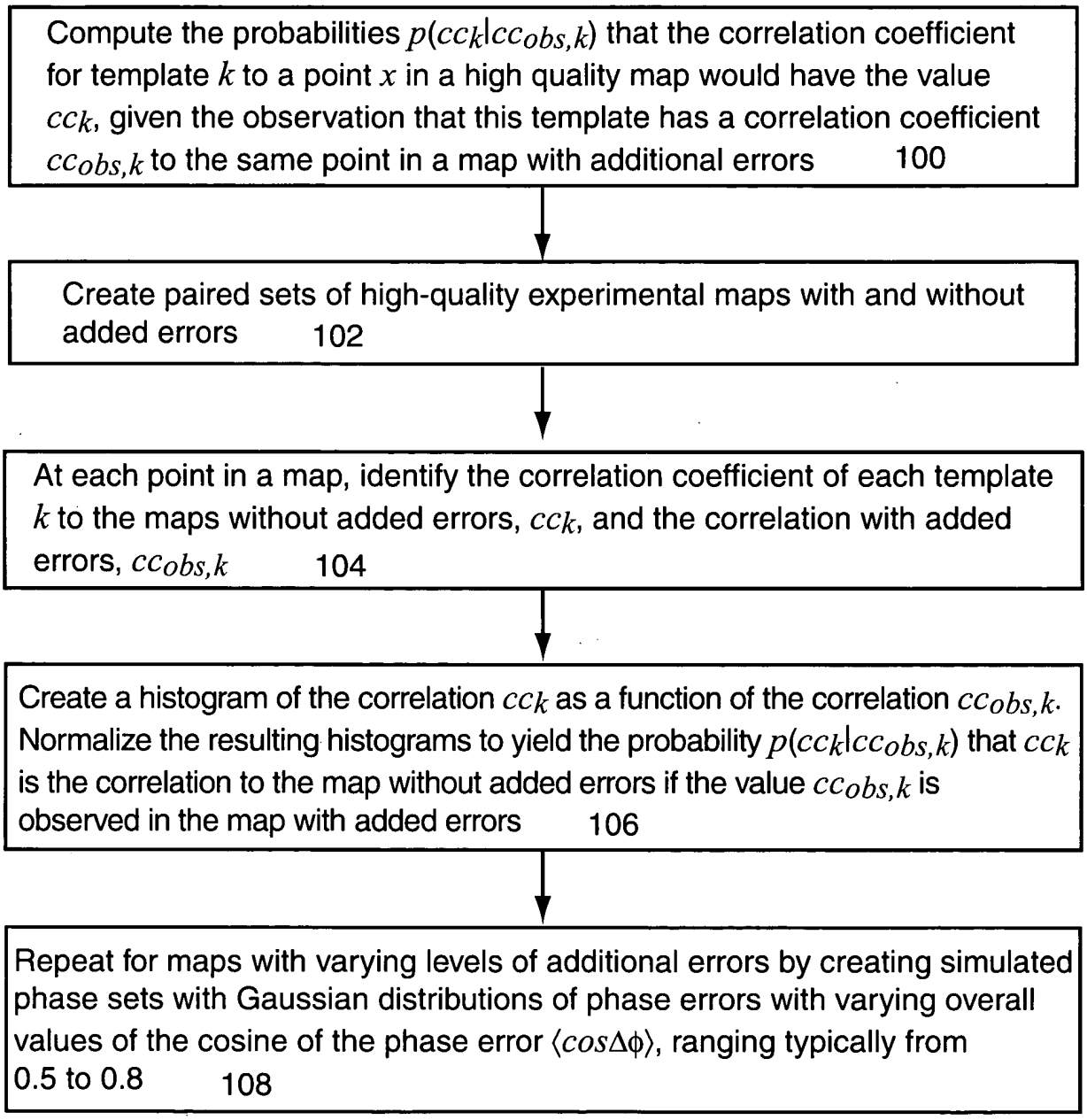
Compute the probabilities $p(cc_k|cc_{obs,k})$ that the correlation coefficient for template k to a point x in a high quality map would have the value cc_k, given the observation that this template has a correlation coefficient $cc_{obs,k}$ to the same point in a map with additional errors 100
Create paired sets of high-quality experimental maps with and without added errors 102
At each point in a map, identify the correlation coefficient of each template k to the maps without added errors, cc_k, and the correlation with added errors, $cc_{obs,k}$ 104
Create a histogram of the correlation cc_k as a function of the correlation $cc_{obs,k}$. Normalize the resulting histograms to yield the probability $p(cc_k|cc_{obs,k})$ that cc_k is the correlation to the map without added errors if the value $cc_{obs,k}$ is observed in the map with added errors 106
Repeat for maps with varying levels of additional errors by creating simulated phase sets with Gaussian distributions of phase errors with varying overall values of the cosine of the phase error $\langle cos\Delta\phi \rangle$, ranging typically from 0.5 to 0.8 108

FIG. 6

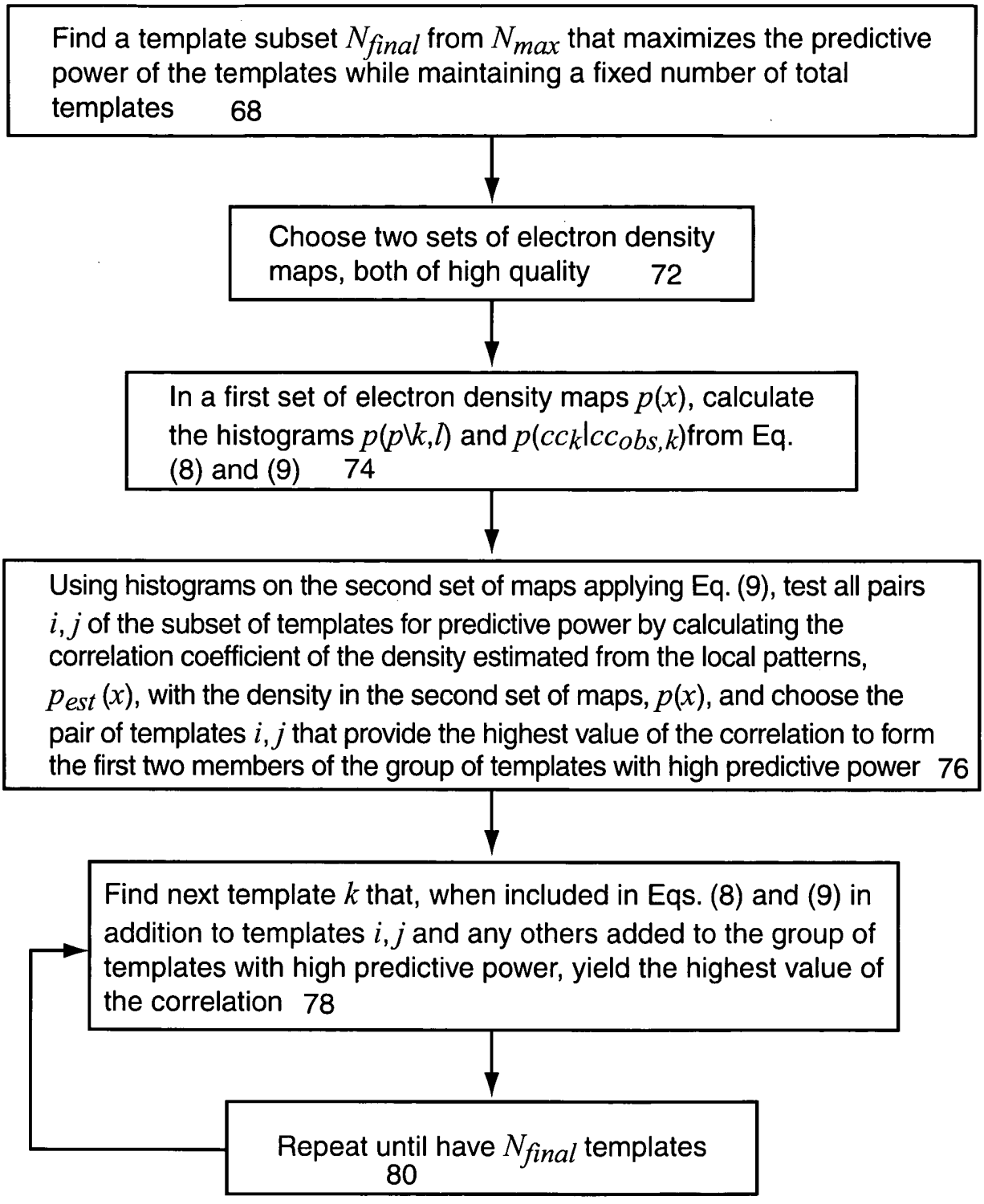
Find a template subset N_{final} from N_{max} that maximizes the predictive power of the templates while maintaining a fixed number of total templates 68
Choose two sets of electron density maps, both of high quality 72
In a first set of electron density maps $p(x)$, calculate the histograms $p(p\backslash k,l)$ and $p(cc_k|cc_{obs,k})$from Eq. (8) and (9) 74
Using histograms on the second set of maps applying Eq. (9), test all pairs i,j of the subset of templates for predictive power by calculating the correlation coefficient of the density estimated from the local patterns, $p_{est}(x)$, with the density in the second set of maps, $p(x)$, and choose the pair of templates i,j that provide the highest value of the correlation to form the first two members of the group of templates with high predictive power 76
Find next template k that, when included in Eqs. (8) and (9) in addition to templates i,j and any others added to the group of templates with high predictive power, yield the highest value of the correlation 78
Repeat until have N_{final} templates 80

FIG. 7

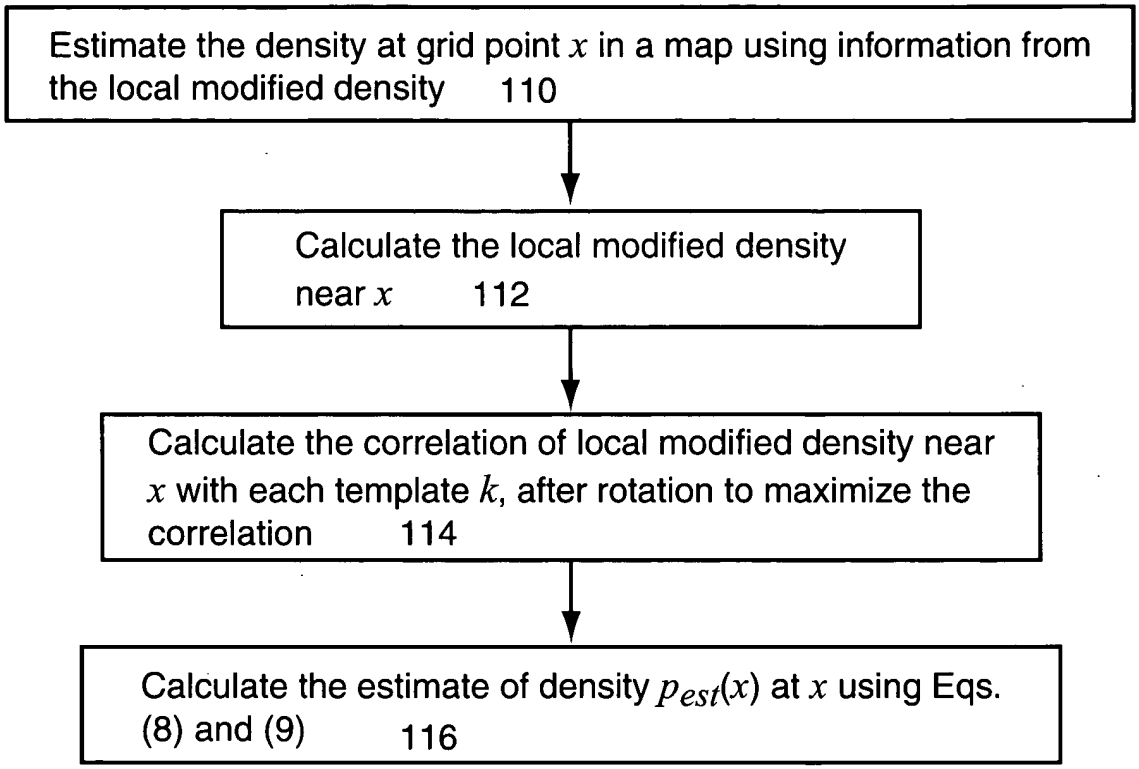
Estimate the density at grid point x in a map using information from the local modified density 110
Calculate the local modified density near x 112
Calculate the correlation of local modified density near x with each template k, after rotation to maximize the correlation 114
Calculate the estimate of density $p_{est}(x)$ at x using Eqs. (8) and (9) 116

FIG. 8

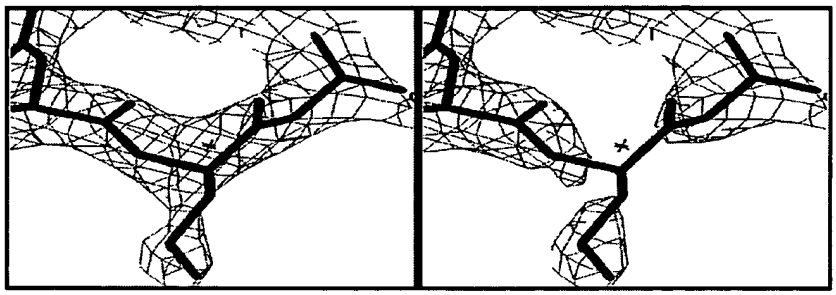

FIG. 9A FIG. 9B

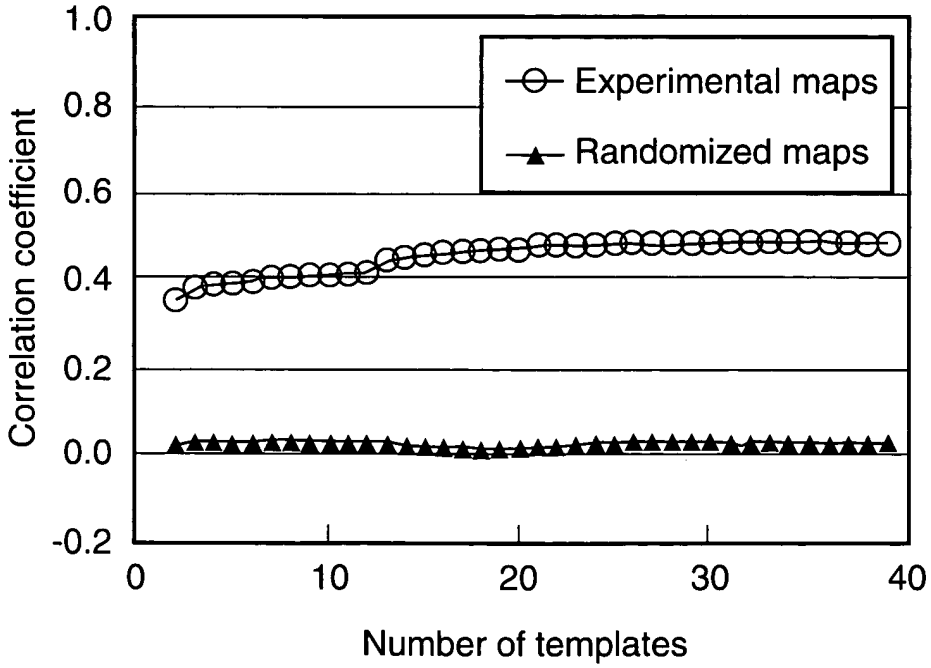

FIG. 10

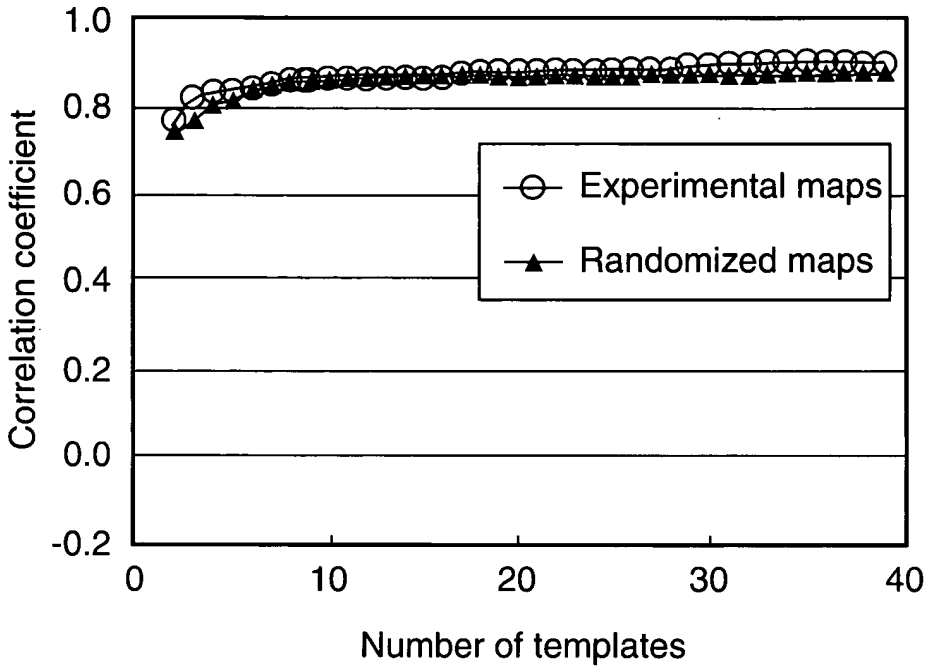
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Correlation coefficient
0
10
20
30
40
Number of templates
Experimental maps
Randomized maps

FIG. 11

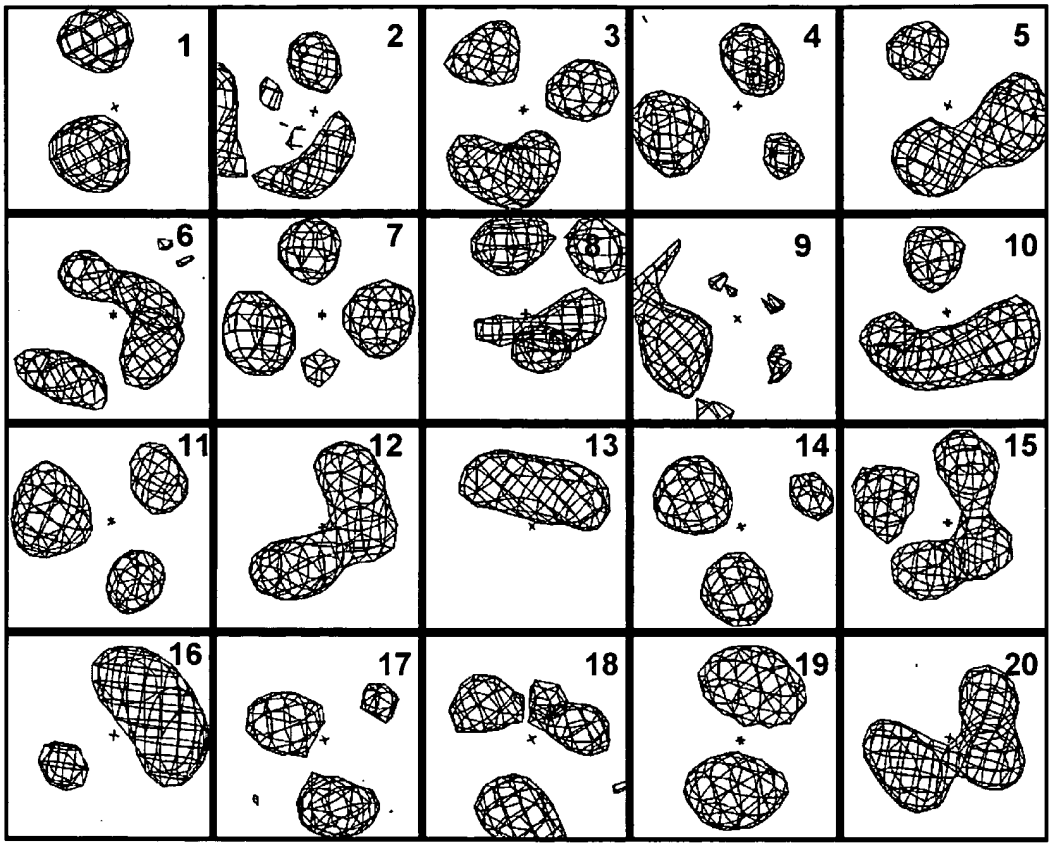

FIG. 12A

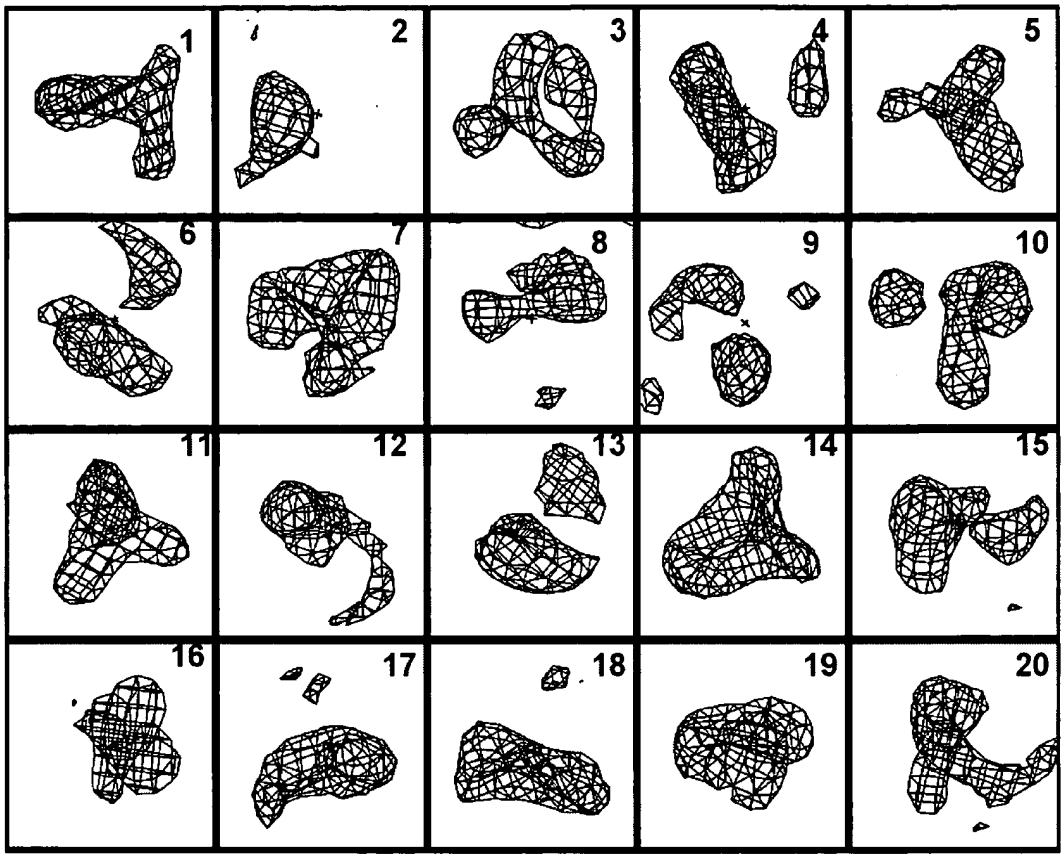

FIG. 12B

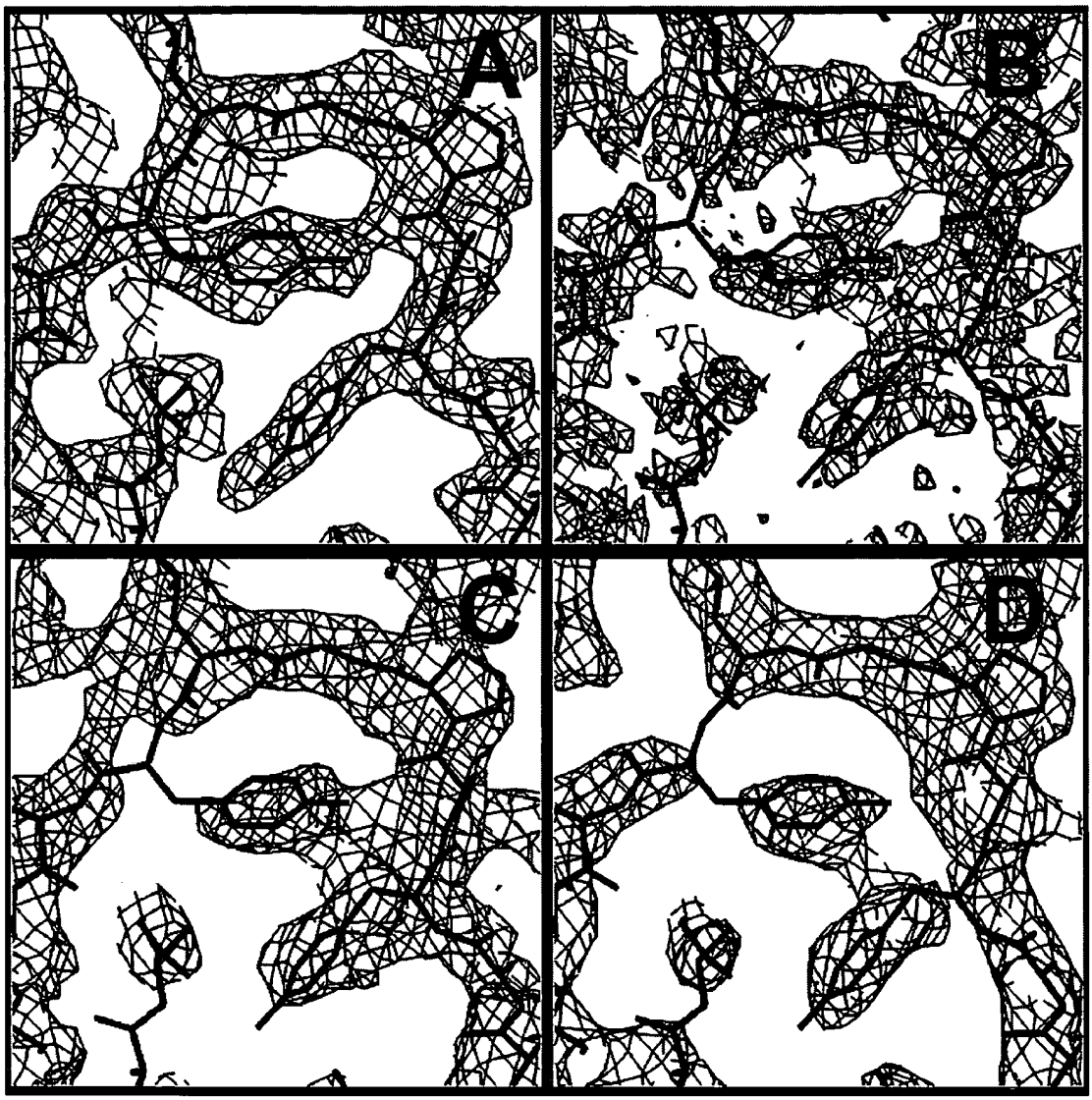

FIG. 13

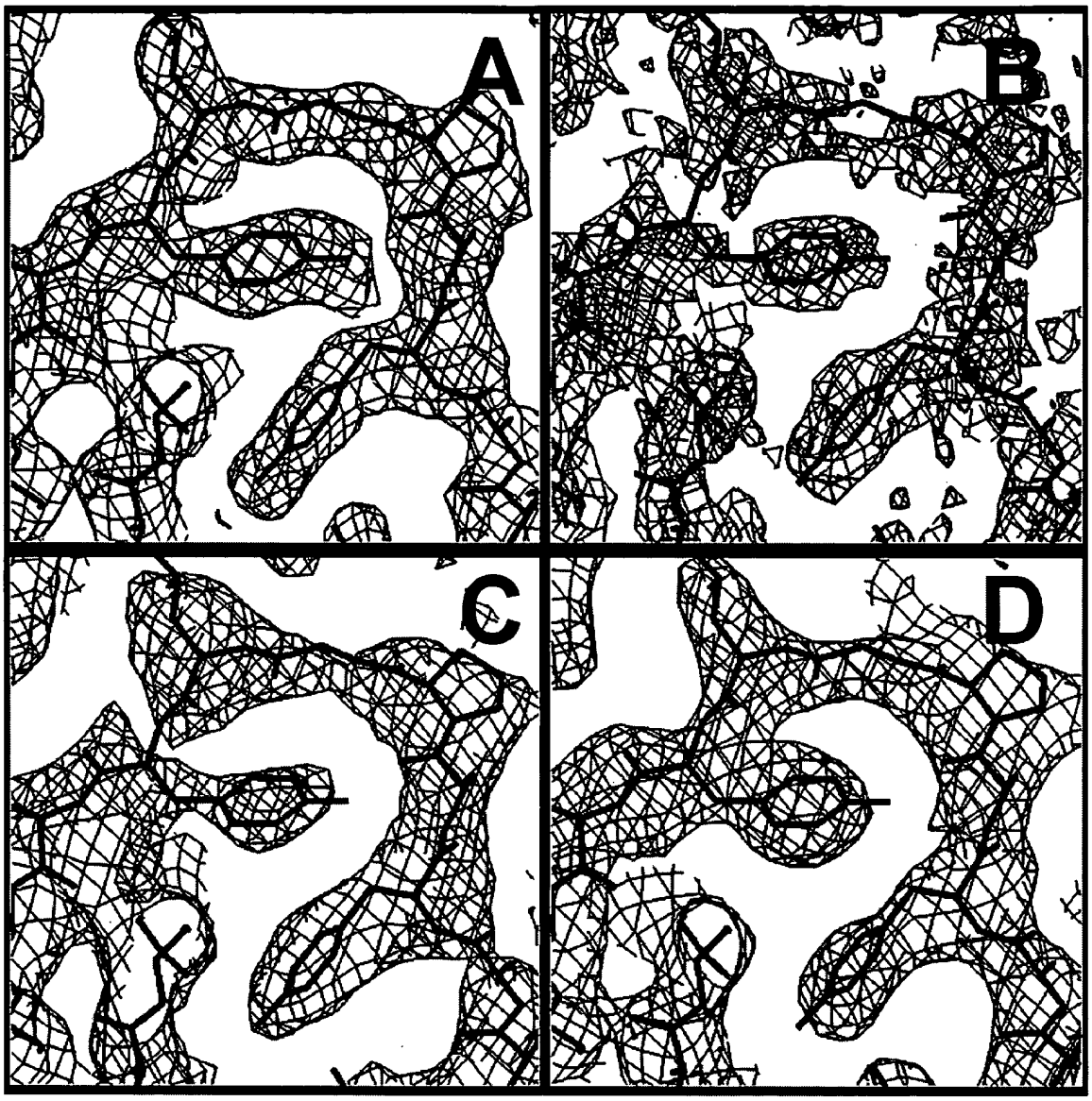

FIG. 14

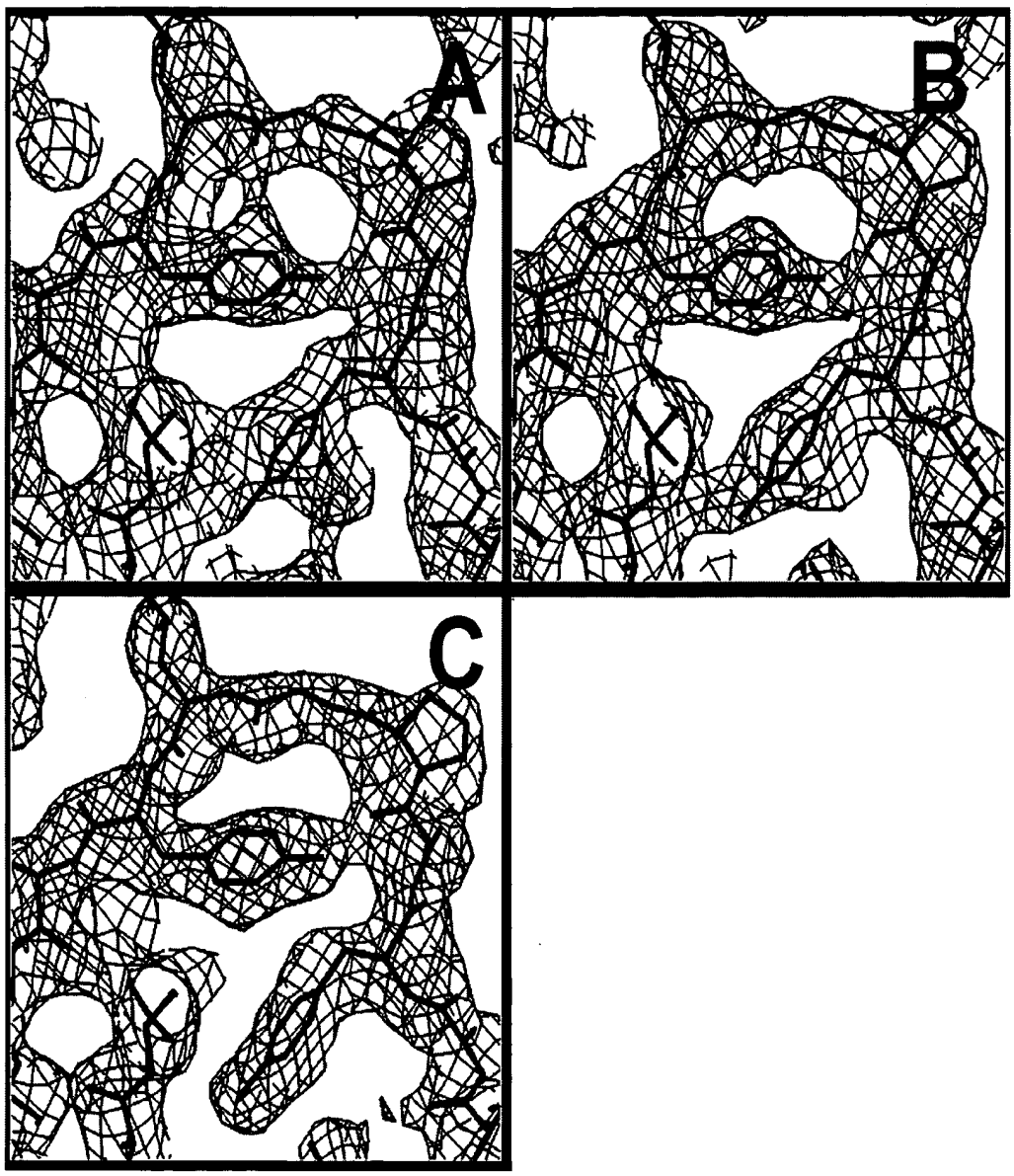

FIG. 15